6.0. INJECTION FLUIDS

ExxonMobil has prepared this petition demonstration to gain authorization from the EPA to inject hazardous waste, as well as non-hazardous waste, into WDW-397 and WDW-398. The primary waste stream currently permitted for injection has a pH of less than 2.0 (Waste Code D002), but is exempt from the Resource Conservation and Recovery Act (RCRA) due to the "Bevill Amendment." Therefore, the existing permits designate the waste stream as non-hazardous. ExxonMobil is submitting this petition demonstration to allow injection of hazardous waste into WDW-397 and WDW-398 as though the waste stream is "non-exempt." If non-exempt, the waste stream is hazardous due to corrosivity ($pH \leq 2.0$) and carries a waste code of D002. The waste stream would also be defined as hazardous due to the presence of a non-exempt constituent, 2,4-dinitrotoluene (D030) that exceeds the toxicity characteristic concentration of 0.13 mg/L. In addition, cadmium has been detected at levels defined as hazardous (> 1.0 mg/L). Table 6-3 lists all of the possible waste codes which could be associated with the hazardous constituents present in the waste stream. Many of the waste codes are not applicable or appropriate with respect to the manner in which the proposed waste stream is generated, but are included in this petition as a matter of completeness. Following is a list of waste codes requested for authorization in this petition demonstration:

D002 D004 D005 D006 D007 D008 D009 D023 D024 D025 D030

F039

This petition demonstration appplication satisfies all regulatory standards and procedures. It shows that the ExxonMobil injection wells meet all necessary requirements for a Class I hazardous waste injection well permit.

6.1. *Waste Generation and Management Activities*

The Agrifos Fertilizer Plant is a manufacturer of solid phosphatic fertilizers and liquid ammonium fertilizer. The plant has the capacity to produce approximately 600,000 tons per year (TPY) of granular diammonium phosphate (DAP) and monoammonium phosphate (MAP) fertilizer and approximately 60,000 TPY of liquid ammonium thiosulfate fertilizer. The plant operates both a sulfuric acid plant and phosphoric acid plant in the manufacture of these fertilizer products. The sulfuric and phosphoric acid plants have a capacity of approximately 600,000 TPY and 280,000 TPY, respectively.

The production of fertilizer begins with mining and subsequent beneficiation of phosphate rock. The phosphate rock is ground into a fine uniform grain size; it is then reacted with sulfuric acid to release the phosphorus from its chemical bond with calcium and other elements. The fertilizer manufacturing process includes the reaction of phosphate rock with sulfuric acid; which produces phosphoric acid and hydrated calcium sulfate (phosphogypsum or gypsum), the major waste by-product in the process. The phosphoric acid is then separated from the phosphogypsum and concentrated. The concentrated phosphoric acid is finally used to manufacture ingredients for inorganic fertilizer including DAP and MAP which are produced when phosphoric acid is reacted with anhydrous ammonia.

Water is added to the waste gypsum to create a slurry that is hydraulically pumped to settling ponds. The ponds contain underdrain systems to collect the pond water as it seeps through the gypsum material built up in the pond. As the ponds fill with gypsum solids, the solids are scooped out to build up the side walls. The side walls of the ponds are continually built up allowing the gypsum to settle out, thus raising the bottom of the pond to form the "gypstack." The phosphoric acid process wastewater ("pond water") that remains in the ponds after the gypsum solids settle out is recycled back into the phosphoric acid production process. The pond water in an operating facility typically has a pH of approximately 1.5 to 2.0. The pond water in an idle gypstack may vary from 1.5 to over 3.0 depending on how long the stack has set idle (no addition of fresh process wastewater).

The major effort in the "closure" of a gypstack involves the management and disposal of the pond water held as ponded surface water on top of the gypstack, and phreatic water contained within the gypstack. Once the pond water is removed from the gypstack, they are closed in a process similar to that of landfills; this includes grading the gypstack to allow positive stormwater run-off, use of liners (natural clay, geosynthetic clay, geomembranes, geocomposites, etc.), evapotransporation (ET) caps (soil and vegetative cover) and/or a combination a liner system and ET cap to reduce the vertical migration of stormwater through the gypstack. Clean stormwater run-off is collected and removed from the gypstack system. Pond water management at this facility will include surface treatment of the pond water for deep well injection into Class I injection wells. The Class I injection wells are located within the boundaries of the Agrifos Fertilizer Plant, on property which is owned by Exxon Mobil Corporation. Deep well disposal of the phreatic pond water from the gypstack will continue after the installation of a cap system on the gypstack until the quality of the seepage water improves to a level that will allow alternative disposal options.

The waste stream proposed for disposal in the ExxonMobil injection wells is the pond water from the gypstacks. The pond water is collected from the gypstacks through an underdrain system in the stacks; the surface pond water seeps through the gypstacks and is collected in the underdrain systems that discharge into toe ditches surrounding the gypstacks, which then discharge into lined collection ponds. During normal phosphoric acid production operations, the pond water is either recycled back into the phosphoric acid production process or returned back to the top of the gypstack. The phosphoric acid production process is a water consumer during normal operations, thus water management in the gypstacks does not require an alternate disposal option for the pond water.

Waste Stream Origination and Description

The primary waste stream proposed for injection into the ExxonMobil injection wells is the process water ("pond water") that remains in the ponds after the gyp-solids settle out and process water collected in the moats surrounding the gypstacks. The process wastewater from the ponds and moats surrounding the gypstacks will vary in pH from 1.4 to 3.0. Two additional minor waste streams proposed for injection include wastewater from the one-time generation of waste during closure of the wells and associated facilities, or from other associated wastes generated on a non-continuous basis.

The process water is exempt from the RCRA under the provisions of the Mining Waste Exclusion of RCRA. The Mining Waste Exclusion of RCRA was established in response to §30 01(b)(3) of the statute, which was added in the 1980 Solid Waste Disposal Act Amendments, more commonly known as the "Bevill Amendment." The citation for the regulations is summarized below:

40 CFR §261.4(b)(7)(ii)(D) and (P)

a. (ii) For the purposes of §261.4(b)(&), solid waste from the processing of ores and minerals includes only the following wastes as generated:
    i. (D) Phosphogypsum from phosphoric acid production;
    ii. (P) Process wastewater from phosphoric acid production.

Although the waste stream for injection is exempt from regulation as a hazardous waste under the Bevill Amendment, the process wastewater also contains 2,4-dinitrotoluene

(2,4-DNT) at concentrations above the toxicity characteristic of 0.13 milligrams per liter (mg/L). The source of the 2,4-DNT is sulfuric acid purchased from an adjacent chemical processing facility. As a result of the fertilizer manufacturing process, the process wastewater contains 2,4-DNT at concentrations above the toxicity characteristic.

The waste streams requested for authorization via this demonstration include the following:

1. Wastes generated during closure of the well(s) and associated facilities that are compatible with permitted wastes, injection zone and the well(s)

2. Gypstack pond water

3. Other associated wastes such as ground water and rainfall contaminated by the above authorized wastes, spills of the above authorized wastes, and wash waters and solutions used in cleaning and servicing the waste disposal well system equipment which are compatible with the permitted waste streams, injection zone and well materials.

Well Closure Wastes

Several very minor wastes (in terms of percent of the total injected volume) are requested as part of this permit application. These include: wastes generated during closure of the well(s) and associated facilities that are compatible with permitted wastes, injection zone and the well(s). These are wastes that will be generated as part of the plugging and abandonment of the proposed injection wells and closure of any injection well related surface facilities. The volume of facility closure wastes will represent a very small portion of the wastes injected over the lifetime of the proposed injection wells.

GypStack Pond Water

The production of fertilizer begins with mining and subsequent beneficiation of phosphate rock. The phosphate rock is ground into a fine uniform grain size; it is then reacted with sulfuric acid to release the phosphorus from its chemical bond with calcium and other elements. The reaction of the phosphate rock with the sulfuric acid produces phosphoric acid and hydrated calcium sulfate (phosphogypsum or gypsum[gyp]), the major waste by-product in the process. The phosphoric acid is then separated from the phosphogypsum and concentrated. The concentrated phosphoric acid is finally used to manufacture ingredients for inorganic fertilizer including DAP and MAP which are produced when phosphoric acid is reacted with anhydrous ammonia.

Water is added to the waste gyp to create slurry that is hydraulically pumped to holding lagoons or ponds. As the lagoons fill, the solids are scooped out to build up the side walls. The side walls of the lagoons are continually built up allowing the gyp to settle out thus raising the bottom of the lagoon to form the "gypstack." The process water ("pond water") that remains in the ponds after the gyp-solids settle out is reused in processing the phosphoric acid. This water has a pH of approximately 1.5 in an active production facility.

The waste stream proposed for injection into the ExxonMobil injection wells is the process water ("pond water") that remains in the ponds after the gyp-solids settle out and process water collected in the moats surrounding the gypstacks.

Other Associated Waste Streams

Several other very minor wastes (in terms of percent of the total injected volume) are requested as part of this permit application. These include: other associated wastes such as ground water and rainfall contaminated by the permitted wastes, spills of the permitted wastes, and wash waters and solutions used in cleaning and servicing the waste disposal well system equipment which are compatible with the permitted waste streams, injection zone and well materials. These are wastes that will be generated during any necessary treatment or stimulation of the proposed injection wells, and the “clean up” of leaks and/or spills of the permitted wastes with. The volume of other wastes will represent a very small portion of the wastes injected over the lifetime of the proposed injection wells.

Naturally Occurring Radioactive Material

The TCEQ has determined that the process water for deep well injection is exempt from regulation as a NORM waste (TCEQ letter dated 8/19/2008). A copy of the letter verifying the NORM waste status is included in Appendix C. Exemption was granted because sampled radium concentrations (radium^{226} and radium^{228}) are below regulatory levels (<60 pC/L).

Chemical Analysis

Table 6-1 summarizes actual analysis of wastewaters collected from the process ponds and moats surrounding the gypstacks. Gypstack pond water samples were collected and analyzed for certain organics, inorganics and heavy metal content. Copies of the analysis are included in Appendix C. The average pH of the analyzed samples is 1.8. The 2,4-dinitrotoluene concentration ranged from 0.279 to 0.430 mg/L (see Appendix C).

pH

The pH of the injected waste streams is expected to average about 1.5. The pH is anticipated to range between 1.4 and 3.0. The acids present in the waste stream include sulfuric acid, phosphoric acid and fluorosilic acid.

Specific Gravity

The anticipated composite waste stream is expected to vary from predominantly freshwater to moderately saline water with minor amounts of various inorganic constituents. Total dissolved solids concentrations of up to 42,000 mg/L have been reported for the process pond water. The specific gravity of the wastewater for injection is expected to range from 1.00 to 1.05 at SATP. This petition demonstration for the ExxonMobil injection wells is made for an injected waste specific gravity of 1.00 to 1.05 at SATP.

Viscosity

The following figure is a plot of viscosity at various temperatures and salinities. Given a waste stream with a specific gravity of between 1.00 (fresh water) to 1.05 (5.5% Na_2SO_4 brine), the viscosity of the waste stream can vary from 0.30 at 200 °F to 1.24 at 60 °F. Although the waste stream is better described as sodium sulfate (Na_2SO_4) brine rather than sodium chloride (NaCl) brine, the figure provides a reasonable approximation for purposes of estimating waste stream viscosity. The various temperature, viscosity and salinity correlations are indicated on the following figure.

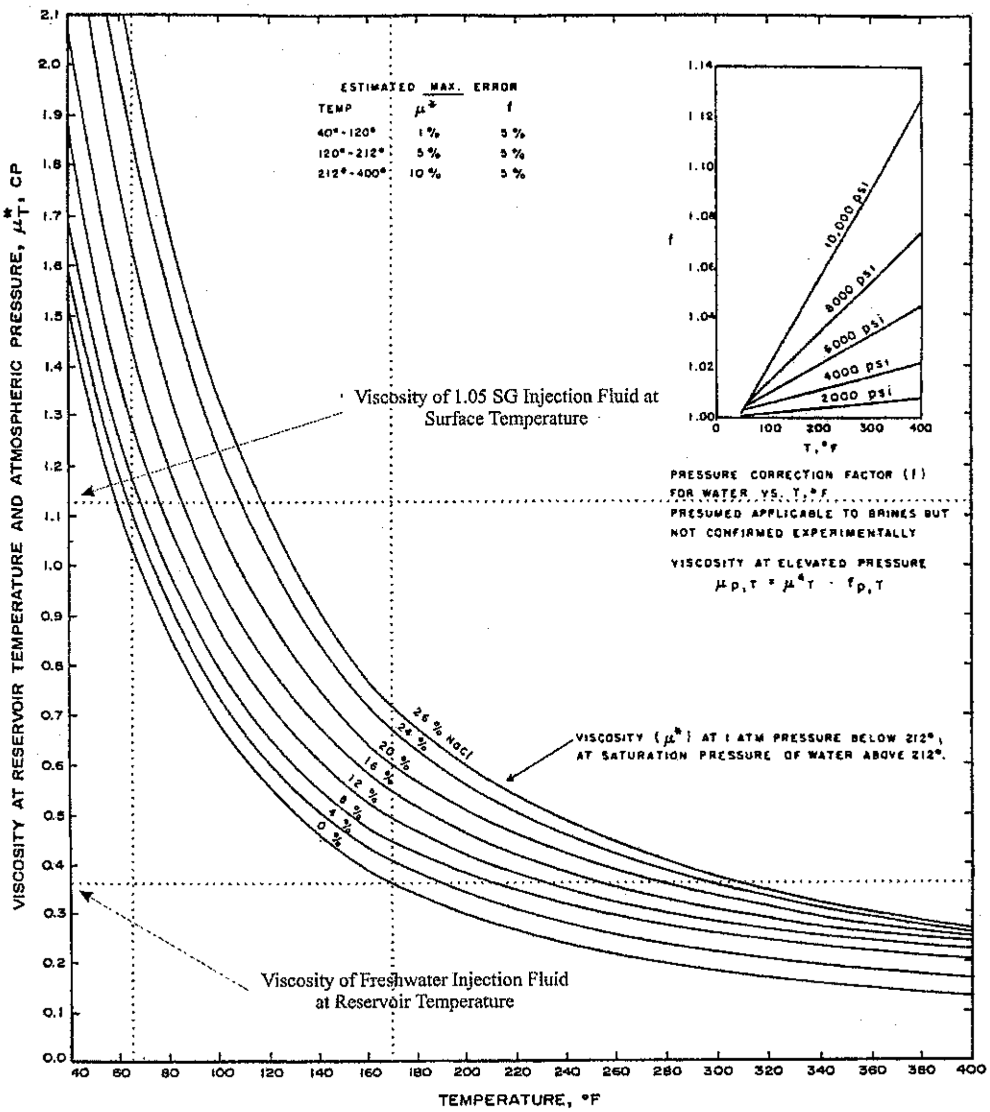

Fig. D. 35 Water viscosity at various salinities and temperatures. After Mathews and Russell, data of Chesnut

Source: Earlougher, R. C., Jr., 1977, Advances in Well Test Analysis, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., p. 241

6.2 Waste Stream Compatibility

This section describes the testing and analysis performed, or planned, to verify compatibility of the proposed waste streams for injection with the Injection Interval formation matrix and reservoir fluids.

6.2.1. Formation Matrix and Wastewater Compatibility

Core data from the Frio Formation was collected at the time of the drilling and completion of the WDW-397 injection well, and the nearby Lyondell, Equistar and Akzo Nobel Class I injection wells. During the drilling and completion of the WDW-397 injection well, whole and sidewall cores were collected. Petrographic analyses of the core material showed a clean, well-sorted, fine to medium-grained sand. The nearest existing injection well facilities to the ExxonMobil facility are located at the Lyondell Chemicals and Equistar Chemicals facilities located in Channelview, Texas approximately 8 miles to the northeast. These injection wells (WDW-148, WDW-162 and WDW-36) are completed into the Frio Formation. During the drilling and completion of the Lyondell WDW-148 injection well, whole and sidewall cores were collected. Petrographic analyses of the core material showed a clean, well-sorted, medium-grained feldspathic litharenite. The Injection Interval core samples were composed of approximately 85 percent quartz, 12 percent feldspar and minor amounts (<3%) of chert and clay minerals. The quartz grains were generally monocrystalline and free of inclusions and showed optically continuous overgrowths at grain boundaries. Orthoclase was the most common feldspar, but plagioclase and microcline were also present. The samples were essentially devoid of matrix material, with secondary quartz overgrowths, secondary feldspar overgrowths and authigenic pyrite acting as a weak, patchy cementing agent.

Injection Interval to Wastewater Compatibility

The recommended injection interval occurs within the Frio Formation. The Frio Formation is composed of several alternating layers of the sand and shale. Formation matrix to injected waste incompatibility problems typically occur due to the swelling nature of the clay minerals contained in the formation. There are basically four predominant varieties of clay minerals present in the subsurface below the ExxonMobil facility location. Of these, montmorillonite is the clay mineral of greatest concern. Montmorillonite is a swelling clay which is sensitive to fresh water and will swell due to hydration when the salinity concentration falls below 30,000 ppm NaCl. It is anticipated that the formation fluid present in the Frio Formation below the facility may have a NaCl content of 105,000 ppm to 115,000 ppm. The gypstack pond water is essentially a $CaSO_4$ wastewater with a TDS content ranging from 4,000 to 40,000 mg/L. Therefore, if montmorillinite clay minerals are present in the injection interval, they may potentially swell when the low salinity, low NaCl gypstack pond water is injected into the formation. The second clay mineral of lesser concern is chlorite. Chlorite can be chemically sensitive to oxygenated waters and hydrochloric acid, which may cause precipitation of pore-blocking ferric hydroxide. Other clay minerals are not reactive to the presence of fresh water and are not of significant concern to this evaluation.

Given the nature of the proposed wastewater for injection, the possibility of swelling clays would be the single issue of concern regarding injected waste to formation matrix compatibility. Assuming that the Frio Formation sands below the subject facility are similar in sand and clay content to the Frio Formation sands below the nearby injection wells, there appears to be a very low probability of significant loss of formation permeability due to the swelling of clays caused by exposure to the proposed wastewater. It is anticipated that the sand intervals of the Frio Formation across which the proposed injection wells will be completed, contain less than 3 percent clay minerals. Given the relatively small amount of clays present, swelling of these clays (montmorillonite) will not significantly alter the permeability of the Injection Interval.

Confining Zone Shale to Wastewater Compatibility

The shale layers present in the Injection Zone and Confining Zone are best described as alumino-silicates, primarily composed of clays and quartz, with smaller amounts of feldspar, carbonates and miscellaneous oxides. A typical Frio shale is composed of approximately 60 percent (or greater) clay minerals and 25 to 30 percent quartz, with the remaining portion composed of feldspars, carbonates and iron oxides (Pettijohn, 1975).

ExxonMobil anticipates no significant formation matrix compatibility problems associated with injection of ExxonMobil wastewaters. The proposed wastewater for injection has a low pH (1.5 to 3.0) due to the presence of sulfuric acid, phosphoric acid and flourosilic acid, but the confining zone minerals (clays and quartz) are not typically reactive to these acids. ExxonMobil collected a whole core of the Confining Zone shale at the time of completion of WDW-397. The core sample was collected from a depth of 5,073 feet to 5,080 feet KB. The shale core was subjected to core flow through compatibility testing. The test results indicated that permeability decreased once the waste stream made contact with the formation matrix. The summary of liquid permeability measurements is included in Appendix C. In some instances, waste streams which are high in volatile and extractable organic constituents may react with the clay minerals which make up shale confining and containment layers, potentially disrupting the confining capabilities of the material. However, the proposed waste stream for injection does not contain volatile or extractable organics. Given the low concentration of organic compounds, the injected waste stream should have no negative impact on the confining capability of the shales. This disregards the fact that the injected waste stream will be effectively diluted with formation brine upon injection and will continue to mix with and be diluted by the formation water after injection operations cease.

6.2.2. Formation Fluid to Wastewater Compatibility

In order to assess the compatibility of the Frio Formation reservoir fluid and the gypstack pond water, Core Lab (5/2002) was contracted to perform fluid/fluid compatibility testing of the subject liquids. The test method was simple in nature and involved the mixing of the gypstack pond water in various ratios with synthesized Frio Formation brine, followed by observation of any reactions between the fluids. Core Labs prepared the synthesized Frio Formation brine based on analytical results of the Frio Formation fluid collected from the Akzo Nobel WDW-139 injection well at the time the well was drilled and completed. Gypstack pond water samples were collected at the facility location and delivered to Core Lab for testing utilization. After mixing the liquids, the liquids were warmed to 125 °F. This temperature was maintained for the duration of the test (24 hours).

After the initial mixing of the fluids, no immediate solids precipitation was observed. After an elapsed time of 4 hours and 24 hours, a minor amount (< 1%) of a cloudy, white precipitate was observed to be forming in the test vessels in the ratio of 3:7, 1:2, and 7:3. No precipitates were observed in the end member mixtures (Core Lab test results are included in Appendixx C-8).

Core Labs analyzed the precipitate and determined that it was composed of malladrite (Na_2SiF_6) which was being precipitated from hydrofluoric acid. In large quantities, the malladrite precipitate could become problematic. However, the amount of precipitate which is generated is minimal (< 1%) and is well within acceptable limits for solids precipitation. ExxonMobil anticipates that there will be little to no deleterious effects to the permeability of the injection interval due to the injection of the gypstack pond water and the subsequent formation of minor amounts of malladrite.

6.2.3. Waste Compatibility With Tubulars and Cement

Corrosion tests of ExxonMobil's waste streams with well materials with which the waste is expected to come into contact have been conducted. The materials tested during this program included Alloy 825, Alloy 20, Alloy 28, Alloy G-30, Alloy 625, Alloy 904L, Alloy C-22, Alloy C-276, Duplex 2507, Duplex 2205, 316L Stainless Steel, K-55, N-80 and 4140 grade carbon steels and 13 Chrome for possible use in flow-wetted portions of this well (lower portion of casing, screen and packer) and Tubular Fiberglass Corporation's fiberglass material for use as the injection tubing. Compatibility testing of cement is not being performed. In areas of the well where cements may come in contact with the injected waste, EPSEAL synthetic cement will be utilized in the lower portion of the well adjacent to the CRA casing and carbon steel casing up to a depth of approximately 5,000 feet. EPSEAL is the most corrosive resistant cement available and should be immune to any deleterious effects caused by contact with the injected waste.

Metals Testing

Corrosion tests for duplicates of the candidate materials coupons specified above were run using 100 percent liquid from the phosphogypsum ponds at test temperatures of approximately 170 °F (approximating the static bottom-hole temperature of the well(s) at total depth). The test method utilized followed NACE Standard TM-01-69 procedures.

Cement Testing

Cement/injection fluid corrosion tests were not performed. EPSEAL cement will be utilized in those portions of the well which may come in contact with the waste stream. EPSEAL is the most corrosive resistant cement available and should be immune to any deleterious effects caused by contact with the injected waste.

Results of Materials Testing

Results of the materials compatibility testing will be summarized in the following table (Possible Construction Materials Corrosion Test Results). Examination of these results indicates that any of the alloys and fiberglass coupons tested should be adequate for use in constructing flow-wetted surfaces of the ExxonMobil injection wells as corrosion caused by contact with waste is minimal and well within acceptable values for corrosion rates.

POSSIBLE CONSTRUCTION MATERIALS CORROSION TEST RESULTS

MATERIAL TYPE	TEST MEDIUM	TEST CONDITION	AVERAGE GENERAL CORROSION RATE (mpy)	LOCALIZED CORROSION
K-55	Phosphogypsum Pond Water	Fully Immersed	66.55	Heavy Pitting and Corrosion
N-80	Phosphogypsum Pond Water	Fully Immersed	69.75	Heavy Pitting and Corrosion
4140	Phosphogypsum Pond Water	Fully Immersed	47.40	Heavy Pitting and Corrosion
13 Chrome	Phosphogypsum Pond Water	Fully Immersed	56.55	Moderate Pitting and Corrosion
316L	Phosphogypsum Pond Water	Fully Immersed	0.035	No Localized Attack
Alloy 20	Phosphogypsum Pond Water	Fully Immersed	0.035	No Localized Attack
Alloy 825	Phosphogypsum Pond Water	Fully Immersed	0.015	No Localized Attack
Duplex 2205	Phosphogypsum Pond Water	Fully Immersed	0.035	No Localized Attack
Alloy 904L	Phosphogypsum Pond Water	Fully Immersed	0.030	No Localized Attack
Alloy 28	Phosphogypsum Pond Water	Fully Immersed	0.020	No Localized Attack
Duplex 2507	Phosphogypsum Pond Water	Fully Immersed	0.025	No Localized Attack
Alloy G-30	Phosphogypsum Pond Water	Fully Immersed	0.010	No Localized Attack
Alloy 625	Phosphogypsum Pond Water	Fully Immersed	0.010	No Localized Attack
Alloy C-22	Phosphogypsum Pond Water	Fully Immersed	0.015	No Localized Attack
Alloy C-276	Phosphogypsum Pond Water	Fully Immersed	0.055	No Localized Attack
TFC Coated	Phosphogypsum Pond Water	Fully Immersed	N/A	No Localized Attack
TFC Uncoated	Phosphogypsum Pond Water	Fully Immersed	N/A	No Localized Attack

The table depicts change in physical weight in terms of corrosion rates. The corrosion rates are expressed in milliliters per year (mpy), the standard unit for reporting corrosion rates for steel and alloy material.

Mpy, or thousandths of an inch per year, is the standard method of reporting corrosion rate for steel and alloy materials. The following scale offers a rating standard which is widely accepted for use in the chemical engineering field.

Excellent	Less than 2 mpy
Good	2 mpy to 10 mpy
Satisfactory	Over 10 mpy to 20 mpy
Borderline	Over 20 mpy to 50 mpy
Unsatisfactory	More than 50 mpy

Comparison results of the corrosion testing (as shown on the table with the rating standard shown above) indicate that the generalized and localized corrosion rates of all of the tested alloys fall in the excellent category. All of the carbon steel materials up to and including the 13 Chrome materials were determined to be unsuitable for use in this application with generalized corrosion rates of approximately 50 mpy and higher and moderate-to-heavy pitting and corrosion (localized corrosion).

Additionally, all the pond water vertical turbine transfer pumps at the Agrifos facility (site where the ExxonMobil injection well(s) will be located) are constructed of 316L Stainless Steel. Furthermore, discussions with representatives from the phosphogypsum industry have stated that 316L Stainless Steel is commonly utilized for pump and pipe materials for use with phosphogypsum process wastewater (pond water). Since compatibility testing, in addition to site-specific applications, suggests that 316L Stainless Steel or higher grade alloys should be acceptable for use in this construction, the lower portion of the casing string consists of SM2535-110 corrosion resistent alloy steel. The injection packer was fabricated using Duplex 2507 alloy material due to its yield strength of approximately 65,000 psi versus the yield strength of 316L Stainless Steel, which is approximately 28,000 psi. The screen was manufactured using Duplex 2507 material for the base pipe with Alloy 825 for the screen wire wrap.

Corrosion Monitoring Plan

ExxonMobil will install a corrosion loop in the injection well facility and will install coupons representing the selected flow-wetted materials of construction in the loop. These coupons will be continuously exposed to the waste stream and will be removed from the loop and examined quarterly to determine corrosion rates for the coupons.

6.3 Injected Waste Volumes and Operating Parameters

The TCEQ UIC Class I injection well permits for WDW-397 and WDW-398 limit the injection rates and volumes to the following:

	WDW-397	WDW-398
Maximum injection rate (gpm)	1,200	1,200
Average injection rate (gpm)	1,200	1,200
Annual injection volume (million gals.)	630.72	630.72
Cumulative maximum injection rate (gpm)	1,200	
Cumulative annual injection volume (million gals.)	630.72	

The cumulative volume injected into WDW-397 and WDW-398 for this petition re-issuance during any given month shall not exceed 52,560,000 gallons. This petition demonstration is made for a cumulative injection volume (WDW-397 and WDW-398) which averages 1,200 gpm (not to exceed 52,560,000 gallons per month, nor 630,720,000 gallons per year.).

The petition model start of operations is July 1, 2008. The petition modeled end of operation for the injection wells is December 31, 2020.

REFERENCES

Earlougher, R. C., 1977, Advances In Well Test Analysis: S.P.E. of the A.I.M.E., Dallas, Texas, 264 p.

EPA, Region VI, 2005, Land Band Health Based Limits Guideline.

Pettijohn, F. J., 1975, Sedimentary Rocks: Harper and Brothers, New York, New York, 526 p.

TABLE 6-1

CHEMICAL ANALYSES OF GYPSTACK POND WATER

Exxon Mobil Corporation
Pasadena, Texas

General Parameters ***Sample Date*** ***Parameter***	Pond Water **3/2002** (moat)	Pond Water **3/28/2002**	Pond Water **5/30/2002**	Pump Pond #4 **2/3/2003** Sample #1	Pump Pond #4 **2/3/2003** Sample #2	Siphon Pond #2/3 **2/3/2003** Sample #3	Pump Pond #2/3 **2/3/2003** Sample #4	Gyp Stack #4 **2/3/2003** Sample #5	Injection Fluid **1/13/2009** Sample Port	Injection Fluid **12/14/2009** Sample Port
pH (units)	2.85	1.67	1.90	1.83	1.29	1.62	1.71	1.71	1.90	1.90
Total dissolved solids	3,380	38,300	40,702	9,730	16,030	10,220	9,350	9,550	30,600	28,100
Total suspended solids	10.0	38.0	0.1	21.0	22.0	36.0	63.0	22.0	206.0	3.6
Arsenic	0.1	2.0	2.3	-	-	-	-	-	2.20	2.01
Barium	-	-	-	<0.25	<0.25	0.30	<0.25	<0.25	-	-
Cadmium	0.03	0.94	1.14	1.10	0.94	0.93	0.80	0.91	1.16	0.88
Calcium	375	1,030	1,176	1,170	1,160	1,420	1,130	1,160	1,310	1,090
Chromium (hexavalent)	ND	0	<0.01	2.7	2.4	4.2	3.0	2.3	<0.0250	0.0137
Cobalt	-	-	-	0.43	0.37	0.28	0.31	0.35	-	-
Copper	0.05	0.84	0.83	0.56	0.49	0.87	0.66	0.47	0.64	0.81
Iron (total)	-	-	-	ND	ND	ND	ND	ND	-	-
Iron (dissolved)	-	-	-	48	49	92	85	48	-	-
Lead	-	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Magnesium	64	198	271	225	225	255	245	230	174	121
Manganese	-	-	-	13	12	10	11	11	-	-
Mercury	0.00	ND	0.36	-	-	-	-	-	<0.00015	<0.00010
Molybdenum	-	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Nickel	0.15	1.89	2.06	1.8	1.6	1.7	1.5	1.5	2.1	1.97
Potassium	-	-	-	310	350	265	300	235	-	-
Sodium	230	1,730	1,850	2,450	2,440	2,300	2,180	2,350	2,060	1,490
Strontium	-	-	-	55	54	51	44	55	-	-
Vanadium	-	-	-	4.0	3.5	4.7	3.9	3.3	-	-
Zinc	0.6	6.8	11.3	6.6	5.9	8.3	6.6	5.6	9.98	8.14
Ammonia-N	103	895	1,343	800	800	1,100	800	800	733	691
Chloride	240	100	109	105	6,410	165	110	100	98.7	<3,000
Fluoride	159	7,300	7,075	6,850	7,400	9,200	7,450	6,950	0.93 ?	2,800
Sulfate	1,440	6,100	5,789	5,370	5,340	5,660	5,260	5,370	5,060	3,930
Phosphorous	305	7,780	84	7,150	6,990	8,560	7,650	7,720	6,720	3,900
Aluminum	-	-	-	16	16	72	58	16	-	-
Boron	-	-	-	1.0	1.1	1.3	1.2	1.3	-	-
Lithium	-	-	-	<0.05	0.41	0.49	0.49	0.43	-	-
Silicon	-	-	-	1,720	1,700	2,150	1,670	1,660	-	-

General Parameters ***Sample Date*** ***Parameter***	Pump Pond #4 **1/10/2004** Collection Pond	Pump Pond #4 **5/3/2004** Collection Pond	Pump Pond #4 **5/19/2004** Collection Pond	Pump Pond #4 **5/19/2004** Top Pond	Pump Pond #4 **12/20/2004** Collection Pond	Pump Pond #4 **1/13/2005** Top Pond North	Pump Pond #4 **1/13/2005** Top Pond South	Pump Pond #4 **1/13/2005** Collection Pond	Injection Fluid **1/13/2009** Sample Port	Injection Fluid **12/14/2009** Sample Port
2,4 dinitrotoluene	0.420	0.295	0.279	0.299	0.430	0.370	0.290	0.360	0.265	<0.0033
o-cresol	-	ND	-	-	-	-	-	-	-	-
m-cresol	-	ND	-	-	-	-	-	-	-	-
p-cresol	-	ND	-	-	-	-	-	-	-	-

Note: all concentrations expressed in mg/l or mg/Kg
ND - not detected
 - not analyzed
? Suspected to be incorrect value

TABLE 6-2

HAZARDOUS CONSTITUENTS IN GYPSTACK POND WATER

Exxon Mobil Company
Pasadena, Texas

SAMPLE NAME SAMPLE DATE Waste Constituent	Pond Water 3/2002 (moat)	Pond Water 3/28/2002	Pond Water 5/30/2002	Pump Pond #4 2/3/2003 Sample #1	Pump Pond #4 2/3/2003 Sample #2	Siphon Pond #2/3 2/3/2003 Sample #3	Pump Pond #2/3 2/3/2003 Sample #4	Gyp Stack #4 2/3/2003 Sample #5	Injection Fluids 1/13/2009 Sample Port	Maximum Concentration	Maximum Petitioned Wellhead Concentration	Health Based Limit	Concentration Reduction Factor
Arsenic	0.1	2.0	2.3	-	-	-	-	-	-	2.3	5,000	5.0E-02	1.00E-05
Barium	-	-	-	<0.25	<0.25	0.30	<0.25	<0.25	-	0.3	200,000	2.0E+00	1.00E-05
Cadmium	0.03	0.94	1.14	1.10	0.94	0.93	0.80	0.91	1.16	1.2	500	5.0E-03	1.00E-05
Chromium	ND	0	<0.01	2.7	2.4	4.2	3.0	2.3	<0.025	4.2	10,000	1.0E-01	1.00E-05
Lead	-	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05	100	1.0E-03	1.00E-05
Mercury	0.00	ND	0.36	-	-	-	-	-	<0.00015	0.4	200	2.0E-03	1.00E-05
Nickel	0.15	1.89	2.06	1.8	1.6	1.7	1.5	1.5	2.1	2.1	100	1.0E-03	1.00E-05
Vanadium	-	-	-	4.0	3.5	4.7	3.9	3.3	-	4.7	400	4.0E-03	1.00E-05

SAMPLE NAME SAMPLE DATE Waste Constituent	Pump Pond #4 1/10/2004 Collection Pond	Pump Pond #4 5/3/2004 Collection Pond	Pump Pond #4 5/19/2004 Collection Pond	Pump Pond #4 5/19/2004 Top Pond	Pump Pond #4 12/20/2004 Collection Pond	Pump Pond #4 1/13/2005 Top Pond North	Pump Pond #4 1/13/2005 Top Pond South	Pump Pond #4 1/13/2005 Collection Pond	Injection Fluids 1/13/2009 Sample Port	Maximum Concentration	Maximum Petitioned Wellhead Concentration	Health Based Limit	Concentration Reduction Factor
2,4 dinitrotoluene	0.420	0.295	0.279	0.299	0.430	0.370	0.290	0.360	0.265	0.4	200	2.0E-03	1.00E-05
o-cresol	-	ND	-	-	-	-	-	-	-	ND	180,000	1.8E+00	1.00E-05
m-cresol	-	ND	-	-	-	-	-	-	-	ND	180,000	1.8E+00	1.00E-05
p-cresol	-	ND	-	-	-	-	-	-	-	ND	1,000	1.0E-02	1.00E-05

* detection limit stated for vanadium and p-cresol

TABLE 6-3

HAZARDOUS CONSTITUENTS IN EXXONMOBIL WASTESTREAM

Exxon Mobil Corporation
Houston, Texas

REGION 6 - LAND BAN HEALTH BASED LIMITS GUIDELINE - Revised 4/25/2005

CAS No.	Possible Waste Codes	Chemical Name	Reference Molecule	Land Ban HBL (mg/L)	Source	Detection Limit (1) (mg/L)	SW-846 Test Method	Maximum Petitioned Wellhead Concentration (mg/l)	Concentration Reduction Factor
7440-38-2	D004, F039	Arsenic		5.0E-02	MCL			5,000	1.0E+05
7440-39-3	D005, F039	Barium		2.0E+00	MCL			200,000	1.0E+05
7440-43-9	D006, F039	Cadmium		5.0E-03	MCL			500	1.0E+05
7440-47-3	D007, F039	Chromium		1.0E-01	MCL			10,000	1.0E+05
108-39-4	D024, F039	m-Cresol (3-Methylphenol)		1.8E+00	RfD			180,000	1.0E+05
95-48-7	D023, F039	o-Cresol (2-Methyphenol)		1.8E+00	RfD			180,000	1.0E+05
106-44-5	D025, F039	p-Cresol (4-Methylphenol)				1.0E-02	8270	1,000	1.0E+05
121-14-2	D030, F039	2,4-Dinitrotoluene		2.0E-03	RSD			200	1.0E+05
7439-92-1	D008, F039	Lead				1.0E-03	7421	100	1.0E+05
7439-97-6	D009, F039	Mercury		2.0E-03	MCL			200	1.0E+05
7440-02-0	F039	Nickel				1.0E-03	7521	100	1.0E+05
7440-62-2	F039	Vanadium				4.0E-03	7911	400	1.0E+05

Footnotes: (1) The Practical Quantitation Limit (PQL) was employed when available, using a ground water matrix.

Notes: HBL taken from MCL, lower of RfD/RSD, detection, or surrogate detection limit in this order of preference.
MCL - Maximum Contaminant Level
RfD - Reference Dose
RSD - Risk Specific Dose

MCL taken f/ Drinking Water Regulations & Health Advisories, 10/96.

RfD and RSD taken from IRIS, 3/97.

$$\text{RfD (mg/L)} = \frac{\text{RfD (mg/kg/day)} \times 70\text{kg}}{2\ \text{L/day}}$$